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SURVEYS OF GROOVES IN 19 BITUMINOUS RUNWAYS.(U)
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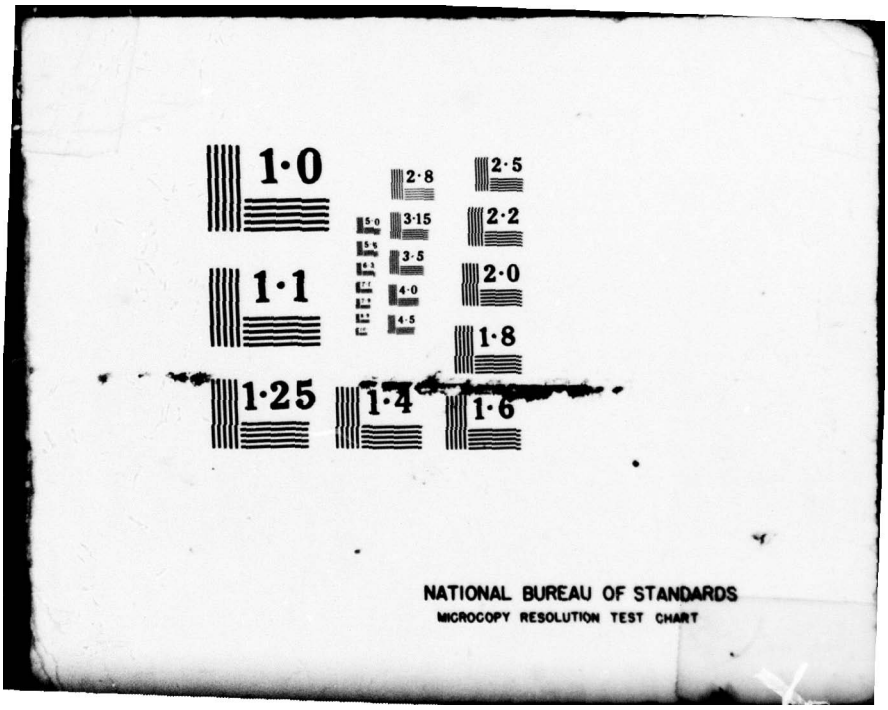
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

Report No. FAA-RD-79-28

LEVEL II

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SURVEYS OF GROOVES IN 19 BITUMINOUS RUNWAYS

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Naval Air Engineering Center
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March 1979

Final Report

Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
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16. Abstract

This report presents the results of a survey of grooves cut into the bituminous runway surfaces at 19 airports throughout the eastern half of the United States. The survey was conducted during the period 20 March 1978 to 25 May 1978. The objectives of the survey were to determine the extent and frequency of problems, such as chipping, cracking, rounding, wearing, distorting, and contaminating of the grooves.

A total of ten different problem areas was identified during the survey with wear, "running together" (closing), and rubber deposits being the most serious of the ten. In general, the grooves were in satisfactory condition and have not resulted in abnormal deterioration of runway surfaces. Three of the 19 runways surveyed appeared in need of resurfacing and/or regrooving. Groove depths averaged less than the required 1/4 inch, while groove width and pitch measured close to specified dimensions.

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I INTRODUCTION

A. Since the mid 1960's, transverse pavement grooves have been cut into runway surfaces to channel water and reduce hydroplaning, thus improving aircraft braking and steering capabilities in wet weather. The grooves are saw cut into both concrete and bituminous surfaces with a recommended pattern of 1/4-inch deep by 1/4-inch wide with a center-to-center distance (pitch) of 1-1/8 to 2 inches (see reference a). The FAA has received reports from several sources which indicate that grooves cut in bituminous runways are deteriorating. They have, therefore, requested that the Naval Air Engineering Center by amendment to Inter-agency Agreement DOT-FA74WAI-423, conduct a survey of airports with grooved bituminous runways. The object of the survey being to determine the seriousness, the extent and frequency of problem areas in grooved bituminous pavement, such as:

1. "Running together" (closing).
2. Chipping, rounding, and cracking.
3. Deformations, distortions in groove pattern.
4. Climatic effects.
5. Contaminants, wear, and loading.

B. In response to the FAA request, the NAEC Test Department, Code 9421 prepared a proposal for the Runway Groove Survey (reference b) which was submitted to and approved by the FAA. The proposal specified the following inspection method:

II INSPECTION METHOD

A. The entire grooved portion of the runway will be surveyed. Particular attention will be paid to touchdown, braking and turning areas, and to specific problem areas reported to the FAA.

B. When a defective area is located, the procedure will be as follows:

1. Estimate extent of defective area.
2. Note area on runway layout.
3. Determine nature of defects, that is, classify as:
   a. Running together.
   b. Chipping, rounding, cracking.

c. Deformation of groove pattern.

d. Contaminated (with rubber, sand, etc.).

e. Wearing.

f. Crushing.

g. Other.

C. Measurement of grooved depth, width, and spacing, will be made where necessary.

D. The defective areas will be photographed when necessary. In addition, a survey questionnaire, see enclosure (1), was administered to personnel at each airport.

III LIST OF RUNWAYS INSPECTED

The initial list of runways to be inspected, as supplied by the FAA, is shown below. The modified list is shown in Table I.

Airport	State	Runway
Newark International	NJ	4L/22R
Philadelphia International	PA	9R/27L
Lovell Field (Chattanooga)	TN	2/20
JFK International	NY	13L/31R
La Guardia	NY	4/22
Miami International	FL	9L/27R
Ft. Lauderdale International	FL	9L/27R
Herlong (Jacksonville)	FL	7/25
Allentown-Bethlehem-Easton	PA	6/24
Erie International	PA	6/24

Airport	State	Runway
Cleveland-Hopkins International	OH	5R/23L
Greater Pittsburgh International	PA	10R/28L
Kanawha (Charleston)	WV	5/23
Greater Cincinnati	OH	18/36
Albany County	NY	1/19
Logan International (Boston)	MA	4L/22R
O'Hare International (Chicago)	IL	4L/22R
Detroit Metropolitan Wayne Co.	MI	3R/21L
Minneapolis-St. Paul International	MN	11L/29R
Washington National	DC	15/33

This list was eventually modified for the following reasons:

A. NEWARK INTERNATIONAL RUNWAY 4L/22R--

On the day of inspection, the parallel runway 4R/22L was down for maintenance. This doubled the traffic on 4L/22R and made inspection of that runway unfeasible. Runway 4R/22L, which is a 9,800-foot bituminous runway grooved in 1973, was inspected in lieu of Runway 4L/22R which is 8,200 feet in length and grooved in 1970.

B. HERLONG (JACKSONVILLE) 7/25-- This airport was mistakenly included in the original list. The intended runway for inspection was Jacksonville International Runway 7/25.

C. CLEVELAND-HOPKINS INTERNATIONAL RUNWAY 5R/23L--

This runway was overlaid just prior to our inspection and was not yet regrooved. As a substitute, Runway 10L/28R was inspected. This runway is 6,000 feet long and was grooved in 1974.

D. LOGAN INTERNATIONAL RUNWAY 4L/22R--

This runway was unavailable for inspection due to heavy traffic. Runway 15R/33L, which is 10,000 ft. and grooved in 1972 and 1973, was inspected instead. 4L/22R is 7,800 feet and was grooved in 1975.

E. CHICAGO-O'HARE INTERNATIONAL RUNWAY 4L/22R

This runway was unavailable for inspection due to heavy traffic. Runway 14L/32R, which was closed for resurfacing, was inspected instead. Runway 4L/22R is 7,500 feet and grooved in 1976, Runway 14L/32R is 10,000 feet and grooved in 1974.

F. DETROIT METROPOLITAN WAYNE COUNTY RUNWAY 3R/21L

The airport was mistakenly included in the original list. There are no bituminous grooved runways at Detroit Metropolitan. All runways are concrete.

G. MINNEAPOLIS-ST. PAUL INTERNATIONAL RUNWAY 11L/29R

Runway 11L/29R is concrete. Runway 11R/29L, which is 10,000 feet bituminous was inspected instead.

The actual list of runways which were inspected during the survey along with the various groove patterns as specified by the airports is shown in Table I on the next page.

IV GROOVE PROBLEMS, DEFINITIONS

In conducting the survey of 19 airports, ten factors were identified as groove problems or possible groove related problems. A record of each occurrence of these factors was made showing severity and location on the runway. The factors are:

A. WEAR -- Groove depth measuring 1/8 inch or less (all were supposed to be 1/4 inch). (See Figure 1)

B. CLOSING -- Groove width was 3/16 inch or less (1/4 inch is called for) or noticeably lipped over. (See Figure 2)

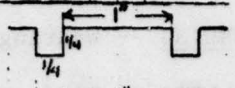
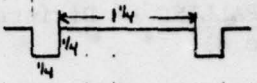
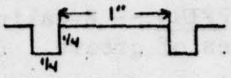
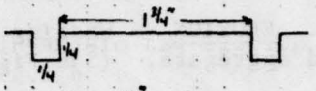
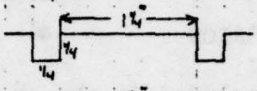
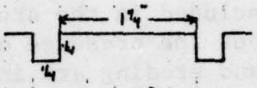
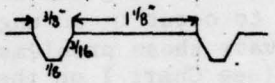
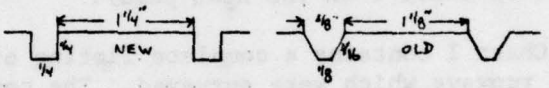
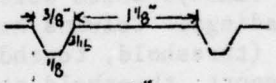
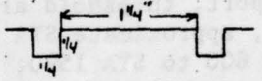
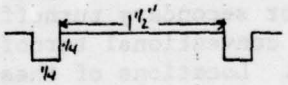
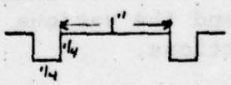
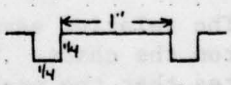
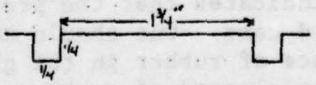
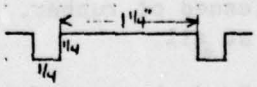
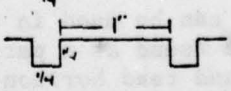
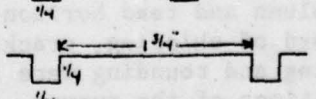
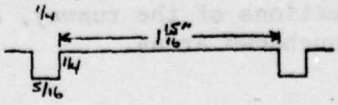
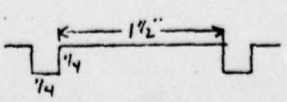
C. RUBBER --Rubber in grooves themselves, not just on surface. (See Figure 3)

D. CRACKING -- Reflective (from concrete subsurface) or cold seam cracks were not noted; however, where cracks propogated along grooves a record was generally made. (See Figure 4)

E. MIGRATING -- Flowing of asphalt resulting in a wavy groove pattern which may affect water runoff rate. (See Figure 5)

F. DEEP/SHALLOW CUT -- Adjacent grooves of different depths because of improper control of cutting blade heights or non-level surface. (See Figure 6)

TABLE I

	AIRPORT/RUNWAY		GROOVE PROFILE	PITCH
①	CHATTANOOGA (LOVELL FIELD)	2/20		1 1/4"
②	GREATER CINCINNATI	18/36		1 1/2"
③	PHILADELPHIA INT'L	9R/27L		1 1/4"
④	JACKSONVILLE INT'L	7/25		2"
⑤	FT LAUDERDALE-HOLLYWOOD INT'L	9L/27R		1 1/2"
⑥	MIAMI INT'L	9L/27R		1 1/2"
⑦	J. F. K. INT'L	13L/31R		1 1/2"
⑧	LA GUARDIA	4/22		1 1/2"
⑨	NEWARK INT'L	4R/22L		1 1/2"
⑩	ALLENTOWN-BETHLEHEM-EASTON	6/24		1 1/2"
⑪	GREATER PITTSBURGH INT'L	10R/28L		1 3/4"
⑫	CHARLESTON, W VA (KANAWHA)	5/23		1 1/4"
⑬	ALBANY COUNTY	1/19		1 1/4"
⑭	ERIE INT'L	6/24		2"
⑮	CLEVELAND-HOPKINS INT'L	10L/28R		1 1/2"
⑯	CHICAGO-O'HARE INT'L	14L/32R		1 1/4"
⑰	MINNEAPOLIS-ST PAUL INT'L	11R/29L		2"
⑱	BOSTON-LOGAN INT'L	15R/33L		2 1/4
				PITCH
⑲	WASHINGTON NATIONAL	15/33		1 3/4

G. ROUNDING -- Wearing away of sharp groove edges. (See Figure 7)

H. SPALLING -- Disintegration, breaking up of asphalt surface. (See Figure 8)

I. CHIPPING -- Breaking away of aggregate and/or filler material in sharp edges of groove. (See Figure 9)

J. EROSION -- Washing out of fine filler or binder material leaving exposed aggregate. (See Figure 10)

V DISCUSSION

A. Included in the above listed problems are several which would occur without the presence of grooves. Wearing, cracking, migrating, spalling, and eroding are inherent to bituminous pavements and are just as likely to occur to an ungrooved surface. However, since grooving may aggravate these problems they are being considered potential groove problems (see Chart I on the next page).

B. Chart I contains a complete listing of all problems encountered at the 19 runways which were surveyed. The ten problem areas are the column headings. Columns have then been subdivided into four major runway areas (threshold, touchdown, braking, and turning). For the purposes of this report, threshold areas are aircraft turn-on areas at each end of the runway, approximate STA 0 to STA 300; touchdown areas are approximately STA 800 to STA 1500; braking areas are usually just prior to primary or secondary turnoffs; turning areas are located at both high-speed or conventional turnoffs and in some cases at cross runways or taxiways. Locations of these four areas were determined jointly by the survey team and the various airport personnel who participated in the actual inspections.

1. The relative severity or extent of each problem cannot be determined from the chart. However, the fact that the problem was noted indicates that the problem is fairly extensive and not just an isolated case. One should keep in mind in studying the chart that the incidence of rubber in the grooves is highly dependent on when the runway was last cleaned of rubber. Some runways were cleaned twice a year and others not at all.

Chart I can be used in the following manner. To determine what problems were found at a particular runway, locate the runway in the left hand column and read horizontally. For instance, JFK Runway 13L/31R, had no record of chipping, cracking, erosion, spalling, closing, or rubber; migrating and rounding were found in the braking area, wear was found in all sections of the runway, and deep/shallow cuts were found in threshold and touchdown areas.

AIRPORT RUNWAY NO.		CHIPPING				MIGRATING				ROUNDING				CRACKING				WEAR				EROSION				SPALLING				CLOSING				DEEP/SHALLOW CUT				RUBBER*		
		THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	BRAKING	TURNING
CHATTANOOGA (LOVELL FIELD)	2/20					X												X												X							X		
GREATER CINCINNATI	18/36		X									X		X	X	X				X	X													X					
PHILADELPHIA INTL	9R/27L										X										X						X							X	X	X				
JACKSONVILLE INTL	7/25					X	X												X	X										X							X	X	X
FT LAUDERDALE-HOLYWOOD INTL	9L/27R					X	X	X	X										X											X	X	X						X	X	
MIAMI INTL	9L/27R						X				X	X																		X	X	X	X					X	X	X
JFK INTL	13L/31R						X				X							X	X	X	X													X	X					
LA GUARDIA	4/22																		X	X											X							X		
NEWARK INTL	4R/22L					X												X	X	X														X	X	X	X		X	
ALLENTOWN-BETHLEHEM-EASTON	6/24					X		X		X	X	X						X			X									X	X	X	X			X	X		
GREATER PITTSBURGH INTL	10R/28L						X							X	X	X	X	X	X	X	X					X	X			X		X		X						
CHARLESTON WVA (KANAWHA)	5/23			X																																				
ALBANY COUNTY	1/19		X															X		X		X	X	X							X	X	X							
ERIE INTL	6/24													X	X	X	X																					X		
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CHICAGO-O'HARE INTL	14L/32R													X	X	X	X	X	X	X	X										X							X	X	
MINNEAPOLIS-ST. PAUL INTL	11R/29L					X									X	X		X		X										X	X	X			X			X	X	
BOSTON-LOGAN INTL	15R/33L	X	X			X	X																			X	X			X	X	X						X	X	
WASHINGTON NATL	15/33	X	X											X								X	X				X			X	X							X	X	

* Existence of rubber deposits dependent on when runway was last cleaned.

CHART I - LOCATION OF GROOVE-RELATED PROBLEMS

2. If more specific data are required for a particular runway, the inspection data sheets in Appendix A and the individual runway survey reports, Appendix B, can be referred to.

3. The following comments are also evident from Chart I,

a. Wear, closing, rubber, and cracking are the most common problems.

b. Chipping, rounding, erosion, and spalling are the least common problems.

c. Chipping was found only in touchdown and braking areas.

d. Migrating is most common in threshold areas.

e. Rounding is most common in braking areas.

f. Cracking was found in all runway areas and was limited to cold-weather airports.

g. Rubber deposits were found mainly in touchdown and braking areas.

h. Touchdown and braking areas were, in general, the most heavily damaged, while turning areas suffered the least damage.

C. To further analyze the data presented in Chart I, Chart II through VIII have been prepared. The purpose of these charts is to separate the various airports surveyed into characteristic groups so that comparisons can be made. The characteristics selected for comparison are:

Chart II: High-use versus low-use airports

Chart III: Cold-weather versus warm-weather airports

Chart IV: Warm-weather high-use airport versus warm-weather low-use airport

Chart V: Cold-weather high-use versus cold-weather low-use airports

Chart VI: Runways with groove pitch less than 1-1/2 inches versus runways with groove pitch greater than 1-1/2 inches.

Chart VII: Runways grooved in 1973 or earlier versus runways grooved 1974 or later.

Chart VIII: Runways 10,000 feet or longer versus runways 6,300 feet or less

D. Chart II compares runways surveyed at high-use airports including Washington National, Boston-Logan, O'Hare, Newark, Pittsburgh, Philadelphia, JFK, Miami, and La Guardia with low-use airports including Minneapolis, Ft. Lauderdale, Cleveland-Hopkins, Erie, Allentown-Bethlehem-Easton, Kanawha (Charleston, W. Va.), Chattanooga, Cincinnati, and Jacksonville. Analysis of Chart II (on next page) indicates that:

1. There is no appreciable difference in the incidence of chipping, rounding erosion, or rubber[1] accumulation.

2. Migrating, cracking, and closing do not occur in any greater frequency on the runways at high-use airports and are, therefore, not traffic related.

3. Wear, spalling, and adjacent cuts of deep/shallow[1] grooves are more common on runways at high-use airports.

High-use runways have correspondingly greater amounts of damage than their low-use counterparts. Chart II indicates that this is true only for wear and spalling. For the runways surveyed, chipping, rounding, erosion, migrating, cracking, and closing did not result from heavy aircraft traffic (see Chart II on the next page).

E. Chart III (shown on page 10) compares runways in cold-weather airports (Minneapolis, Boston, Albany, Erie, O'Hare, and Pittsburgh) with runways warm-weather airports (Jacksonville, Miami, Ft. Lauderdale). Only 3 warm-weather airports were surveyed so data is sketchy. Caution must be used in comparing the actual number of problems recorded, since 6 cold-weather sites are being compared with only 3 warm-weather sites. Several trends are apparent.

1. Migrating is most common at warm-weather airports

2. Cracking is most common at cold-weather airports.

3. Chipping, erosion, and spalling were found only at the cold-weather sites visited.

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[1]Further comparisons of these 2 problems will not be considered since rubber deposits are dependent on when the runways were last cleaned, and the incidence of adjacent cuts of deep/shallow grooves are dependent on the cutting machine and/or runway surface level.

CHART II - COMPARISON OF HIGH-USE VERSUS LOW-USE AIRPORTS

	HIGH-USE RUNWAYS*†				LOW-USE RUNWAYS*‡			
FACTORS	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING
CHIPPING	-	2	2	-	-	1	2	1
MIGRATING	2	1	3	-	5	3	2	1
ROUNDING	-	1	3	1	1	1	2	1
CRACKING	2	2	2	2	3	4	4	2
WEAR	4	5	5	4	3	3	4	3
EROSION	1	1	-	-	-	1	1	1
SPALLING	2	3	2	1	-	-	1	-
CLOSING	4	2	6	1	5	5	5	2
DEEP/SHALLOW	4	3	2	1	-	-	3	2
RUBBER	1	6	5	-	-	7	4	1

* Runways were grouped into high- and low-use categories based on the annual estimated air-taxi operations.
† Washington, Boston, O'Hare, Newark, Pittsburgh, Philadelphia, JFK, Miami, and La Guardia.
‡ Minneapolis, Ft Lauderdale, Cleveland, Erie, Allentown-Bethlehem-Easton, Charleston, Chattanooga, Cincinnati, Albany, and Jacksonville.

CHART III - COMPARISON OF COLD-WEATHER VERSUS WARM-WEATHER AIRPORTS

	COLD-WEATHER AIRPORTS*				WARM-WEATHER AIRPORTS†			
FACTORS	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING
CHIPPING	-	1	2	-	-	-	-	-
MIGRATING	2	1	1	-	2	2	2	1
ROUNDING	-	-	-	-	-	1	1	1
CRACKING	3	4	4	3	-	-	-	-
WEAR	3	3	3	3	-	2	1	-
EROSION	-	1	1	1	-	-	-	-
SPALLING	2	2	1	-	-	-	-	-
CLOSING	3	3	5	1	3	2	2	1
DEEP/SHALLOW	1	-	1	-	-	-	-	-
RUBBER	-	4	3	-	1	3	3	1

* Minneapolis, Boston, Albany, Erie, O'Hare, and Pittsburgh.
† Jacksonville, Miami, and Ft Lauderdale.

F. Chart IV and V were prepared to determine the effect of traffic volume in the two climatic extremes. In Chart IV, high-use and low-use airports are compared under the same warm climatic conditions while in Chart V high-use and low-use airports are compared in the same cold climatic conditions.

1. Conclusions drawn from Chart IV (shown on page 12) are not statistically significant, since only 2 airports are involved, but the following trends were noted:

a. Migrating is independent of traffic conditions.

b. Rounding appears to be dependent on traffic conditions.

2. Conclusions reached from Chart V (shown on page 12), which compares runways at Boston, Pittsburgh, and O'Hare airports with runways at Minneapolis-St. Paul, Erie, and Albany airports are as follows:

a. Spalling was limited to higher use airports, and therefore, appears to be traffic dependent.[2]

b. Erosion is apparently not traffic dependent occurring only in low-use airports.[2]

G. Chart VI (shown on page 13) compares four runways with a small pitch of 1-1/4 inches with four runways with a large pitch (2 to 2-1/4 inches). Runways having a small pitch have a greater number of grooves, and therefore, a greater amount of material removed. They should be more susceptible to certain types of damage. In fact, there does appear to be more wear and more erosion on the runways with a small pitch. In addition, small pitch runways had comparatively more damage in the turning areas.

H. Chart VII (shown on page 13) compares eight runways grooved in 1973 or earlier with eight runways grooved 1974 or later. There appears to be no significant difference in the rate of occurrence of chipping, migrating, cracking, spalling, or closing. Wear and rounding occurs to a greater extent on the older runways, while evidence of erosion was found only on the newer runways and is apparently more dependent on the bituminous mix used in the runway than on time.

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[2]A similar conclusion was reached in the analysis of Chart II.

CHART IV - COMPARISION OF WARM-WEATHER HIGH-USE AIRPORT WITH WARM-WEATHER LOW-USE AIRPORT

	WARM-WEATHER AIRPORTS							
	HIGH-USE				LOW-USE			
	MIAMI				FT LAUDERDALE			
FACTORS	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING
CHIPPING	-	-	-	-	-	-	-	-
MIGRATING	-	-	1	-	1	1	1	1
ROUNDING	-	1	1	1	-	-	-	-
CRACKING	-	-	-	-	-	-	-	-
WEAR	-	-	-	-	-	1	-	-
EROSION	-	-	-	-	-	-	-	-
SPALLING	-	-	-	-	-	-	-	-
CLOSING	1	1	1	1	1	1	1	-
DEEP/SHALLOW	-	-	-	-	-	-	-	-
RUBBER	1	1	1	-	-	1	1	-

CHART V - COMPARISON OF COLD-WEATHER HIGH-USE AIRPORTS WITH COLD-WEATHER LOW-USE AIRPORTS

	COLD-WEATHER AIRPORTS							
	HIGH-USE				LOW-USE			
	BOSTON, PITTSBURGH, O'HARE				MINNEAPOLIS, ERIE, ALBANY			
FACTORS	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING
CHIPPING	-	1	1	-	-	-	1	-
MIGRATING	1	1	1	-	1	-	-	-
ROUNDING	-	-	-	-	-	-	-	-
CRACKING	2	2	2	2	1	2	2	1
WEAR	2	2	2	2	1	1	1	1
EROSION	-	-	-	-	-	1	1	1
SPALLING	2	2	1	-	-	-	-	-
CLOSING	2	1	3	-	1	2	2	1
DEEP/SHALLOW	1	-	-	-	-	-	1	-
RUBBER	-	2	2	-	-	2	1	-

CHART VI - COMPARISON OF SMALL-PITCH VERSUS LARGE-PITCH GROOVES

	SMALL PITCH (1-1/4 INCHES) CHATTANOOGA, PHILADELPHIA, O'HARE, ALBANY				LARGE PITCH (2 TO 2-1/4 INCHES) BOSTON, MINNEAPOLIS, ERIE, JACKSONVILLE			
FACTORS	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING
CHIPPING	-	-	1	-	-	-	2	-
MIGRATING	1	-	-	-	3	2	-	-
ROUNDING	-	-	1	-	-	-	-	-
CRACKING	1	1	1	1	1	2	2	1
WEAR	2	2	1	3	1	1	2	-
EROSION	-	1	1	1	-	-	-	-
SPALLING	-	-	-	1	2	1	-	-
CLOSING	1	1	2	1	2	2	2	-
DEEP/SHALLOW	1	1	1	-	-	-	1	-
RUBBER	-	2	1	-	-	4	3	1

CHART VII - COMPARISON OF RUNWAYS GROOVED IN 1973 OR EARLIER WITH RUNWAYS GROOVED IN 1974 OR LATER

	RUNWAYS GROOVED 1973 OR EARLIER*				1974 OR LATER†			
FACTORS	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING
CHIPPING	-	1	2	-	-	1	1	-
MIGRATING	3	1	4	-	4	2	1	1
ROUNDING	1	2	4	2	-	-	1	-
CRACKING	2	2	2	1	-	3	3	3
WEAR	4	4	5	4	3	2	2	3
EROSION	-	-	-	-	2	1	1	1
SPALLING	2	2	1	-	-	1	1	1
CLOSING	4	4	4	2	6	2	4	1
DEEP/SHALLOW	3	2	2	3	1	1	2	-
RUBBER	1	5	4	-	-	6	4	1

* Cincinnati, Miami, JFK, La Guardia, Newark, Allentown-Bethlehem-Easton, Pittsburgh, and Boston.
† Chattanooga, Philadelphia, Jacksonville, Ft Lauderdale, Albany, Erie, Minneapolis, and Washington.

I. Chart VIII (shown on page 15) compares six long runways (10,000 feet or longer) with six short runways (6,300 feet or less). Different pilot technique and/or different types of aircraft traffic may have an effect on this comparison. Chart VIII reveals that wear is much more common in the longer runways and also shows considerably more total damage in the threshold areas of the longer runways. Apparently the heavier braking on the shorter runways does not add appreciably to grooving problems, while wide-body jet traffic, which is common only to the longer runways, does increase damage, particularly in the threshold areas. It should be noted that the longer runways surveyed were mainly high use, while the shorter runways were mainly low use.

J. In surveying the 19 runways, measurements were taken along the edge of each runway in an area of little or no wear to determine groove dimensions as cut. In the vast majority of cases, groove width and pitch measured close to specifications while groove depth measured somewhat less than the specified 1/4 inch. A tolerance of $\pm$1/16 inch is recommended in reference (a) which would give a minimum groove depth of 3/16 inch. Grooving contractors are apparently setting the cutting depths at the minimum 3/16-inch value, since relatively few depth readings of 1/4 inch or greater were recorded. A depth of 3/16 inch was average for unworn areas of the runways surveyed.

K. This report has focused mainly on groove-related problems discovered in the 19 runways surveyed. The overall condition of the grooves should be considered to put the groove situation in proper perspective. In general, the grooved-bituminous runways are in good condition. Airport operators report no surface damage or reduced pavement life which can be attributed directly to grooving and all attest to its effectiveness.

Minor groove damage may restrict water run-off, but hydroplaning will always be reduced unless the groove is completely blocked or destroyed. Only 3 of the 19 runways surveyed were considered to be in questionable condition as far as grooving is concerned. They are: Miami International Runway 9L/27R, JFK Runway 13L/31R, and Greater Pittsburgh International Runway 10R/28L.

Each of these three high-use runways suffered from different problems. At Miami International the grooves on Runway 9L/27R were completely closed together and/or clogged with rubber in threshold, touchdown and braking areas. No channeling of water was possible in most cases. JFK Runway 13L/31R had large areas where grooves were completely worn out. No measurements in excess of 1/8 inch were recorded in areas where grooves remained. At Greater Pittsburgh International Airport, Runway 10R/28L had extensive cracking and spalling throughout its entire length.

Grooves at these three runways were cut in 1972, 1973, and 1973 respectively.

CHART VIII - COMPARISON OF RUNWAYS 10,000 FEET OR LONGER WITH RUNWAYS 6,300 FEET OR LESS

	RUNWAYS							
	10,000 FEET LONG OR LONGER*				6,300 FEET LONG OR LESS†			
FACTORS	THRESHOLD	TOUCHDOWN	BRAKING	TURNING	THRESHOLD	TOUCHDOWN	BRAKING	TURNING
CHIPPING	-	-	-	-	-	2	2	1
MIGRATING	1	-	3	-	1	1	1	-
ROUNDING	-	1	3	1	1	1	1	-
CRACKING	2	3	3	2	2	2	2	2
WEAR	4	3	4	4	1	1	1	2
EROSION	-	-	-	-	1	2	1	1
SPALLING	1	1	1	1	-	1	2	-
CLOSING	3	2	4	1	2	3	4	2
DEEP/SHALLOW	3	2	2	-	-	-	2	1
RUBBER	1	3	3	-	-	4	2	-

* Miami, JFK, Pittsburgh, Philadelphia, O'Hare, and Minneapolis.
† Allentown-Bethlehem-Easton, Charleston, Albany, Erie, Cleveland, and Washington.

L. Repair of Grooved Areas

At several of the runways surveyed, extensive cracking along cold seams and/or along the centerline light wiring trough necessitated repairing the damaged areas with cold patch (see Figures 11 & 12). The patches were typically 10 to 20 feet from the centerline and ran parallel to the centerline for hundreds of feet. No regrooving was attempted where these patches were made. The portion of the existing grooves between the centerline and the patched areas cannot effectively drain. Some effort should be made to regroove these patched areas to match the existing pattern as closely as possible.

VI CONCLUSIONS

A. Grooves at the runways inspected are generally in satisfactory condition.

B. Groove depths were shallower than specified, averaging 3/16 inch or less.

C. Groove widths and pitch were very close to specifications at all runways surveyed.

D. A total of ten groove problems were identified during the survey. They are chipping, migrating, rounding, cracking, wear, erosion, spalling, closing, adjacent cuts of deep/shallow grooves, and rubber deposits.

E. Patched areas running parallel to the centerlines of several runways were not regrooved and effective drainage of water was thereby prevented.

F. Numerous conclusions can be drawn from the data presented in Chart I through VIII. The validity of these conclusions may be statistically in question due to the relatively small sample size (19 runways) and the number of variables involved with the overall analysis. This being the case, conclusions have only been drawn where strong indications or trends are apparent.

1. Conclusions concerning specific problem areas are as follows:

a. CHIPPING - Chipping is a fairly uncommon problem found only in braking and touchdown areas of cold weather runways. There appears to be no relation to traffic volume or runway age.

b. MIGRATING - Migrating is most common in the threshold areas and was found at all the warm weather runways surveyed. There appears to be no relationship between the amount of migrating and traffic volume or groove age.

c. ROUNDING - Among the least common of problems, rounding was found mostly in braking areas and on older runways.

d. CRACKING - Cracking is a fairly common freeze-thaw phenomenon found exclusively on runways at cold weather airports. All areas of the runway seem equally susceptible to this type of damage. Many of the cracks are reflection cracks from a concrete subsurface.

e. WEAR - Wear is the most common of the problems affecting grooved bituminous runways. High-use runways and older runways naturally show a greater amount of wear. There is more wear on runways having a small pitch and on the longer runways.

f. EROSION - Erosion is a relatively uncommon problem occurring at only 2 of 19 runways surveyed. Erosion is most likely dependent on deficiencies in the bituminous mix rather than traffic or climatic conditions.

g. SPALLING - Among the least common of problems, spalling was found mainly on runways at high-use airports and only in cold weather areas.

h. CLOSING - Closing is one of the more common runway groove problems. All areas of the runways in both hot and cold climates are affected. The extent of closing is more pronounced at the warm weather areas.

i. DEEP/SHALLOW CUTS - The incidence of alternate passes of deep/shallow grooves was noted at 8 of the 19 runways surveyed. The problem results from improper alignment of the cutting blade heights or from a non-level runway surface.

j. RUBBER - Rubber deposits and clogging of grooves is perhaps the most serious groove problem of all. Rubber removal operations must be regularly scheduled at most high-use airports. Considerable amounts of rubber were found clogging grooves in threshold and braking areas.

2. Conclusions pertaining to specific sections of the runway follow

a. THRESHOLD - Aircraft turning onto the runway and positioning for takeoff cause considerable migrating, closing, and wear in threshold areas.

b. TOUCHDOWN - Heavy rubber deposits, wear, and closing of grooves were the most common problems found in touchdown areas. Damage was of sufficient magnitude to enhance hydroplaning in many areas.

c. BRAKING - Braking areas of the runways surveyed suffered considerable closing in addition to rubber deposits and wear.

d. TURNING - Turning areas were the least damaged portions of the runways surveyed.

VII RECOMMENDATIONS

On the basis of the survey, the following recommendations are made:

A. Additional surveys of warm weather airports should be conducted. (Only 3 of the 19 runways surveyed were in warm regions.)

B. Rubber removal techniques and scheduling based on the amount of rubber in grooves and on the surface should be investigated.

C. The effect of groove depth on hydroplaning should be investigated to determine when worn runways should be resurfaced and/or regrooved.

D. The recommended groove depth should be changed from $1/4 \pm 1/16$ inch to $1/4 \begin{smallmatrix} +1/16 \\ -0 \end{smallmatrix}$.

E. Patched runway areas should be regrooved.

VIII REFERENCES

A. DOT FAA Advisory Circular 150/5320-12, Methods for the Design, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces, 30 June 1975.

B. NAVAIRENGCEN Test Department Code 94421 Proposal for Runway Groove Survey, 23 January 1978.

IX BIBLIOGRAPHY

1. Anonymous, "Pavement Grooving and Traction Studies". NASA SP-5073, 1969

2. Dept of Transportation, Advisory Circular "Methods for the Design, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces". AC No. 150/5320-12, 1975

3. Gallway, B. M., "Tentative Pavement and Geometric Design Criteria for Minimizing Hydroplaning", Federal Highway Administration Report No. FHWA-RD-75-11, 1975

4. Yager, Thomas J., Phillips, W. P., Horne, Walter B. and Sparks, Howard C. "A Comparison of Aircraft and Ground Vehicle Stopping Performance on Dry, Wet, Flooded, Slush-, Snow-, and Ice-Covered Runways", NASA TN D-6098, 1970

Enclosure (1)

Sample of Groove Survey Questionnaire

Richard Melone
RICHARD MELONE

RUNWAY GROOVE INSPECTION QUESTIONNAIRE REPT NO: NAEC-TD-MISC-R8

1. AIRPORT ALBANY COUNTY 2. INSPECTION DATE: 2 MAY 1978

3. RUNWAY DIRECTION: 1/19

4. AIRPORT CONTACTS:

   a. NAME ROY MC QUEEN PHONE #: 212 995-3747

      JOB TITLE: FAA REGIONAL PAVING ENGINEER

   b. NAME JOHN MASKO PHONE #: 518 869-5312

      JOB TITLE: AIRPORT MANAGER

   c. NAME _____ PHONE #: _____

      JOB TITLE: _____

5. ILS TOUCHDOWN STATION: 1200

6. PRIMARY TURNOFF STATION: 4500

7. SECONDARY TURNOFF STATION: 4000

8. LOCATION OF ANY KNOWN PROBLEM AREAS IN GROOVED SURFACES: NO KNOWN PROBLEM AREAS.

9. COMMENTS: RUNWAY GROOVING COMPLETED OCTOBER 1976. SURFACE HAS NOT BEEN CLEANED SINCE GROOVING WAS COMPLETED.

10. SURVEY CONDUCTED BY: R. MELONE & W. WASTALLO

ENCLOSURE (1)

Figure 1 - Wear (Groove Depth of 1/8 Inch or Less) Identified During Runway Survey

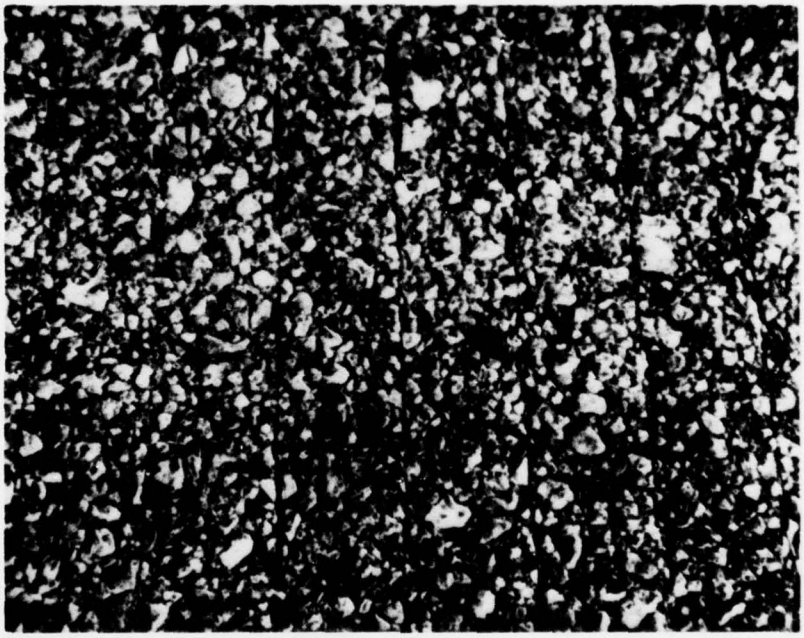

Figure 2 - Closing (Groove Width of 3/16 Inch or Less) Identified During Runway Survey

Figure 3 - Rubber Found in Grooves of Runway During Survey

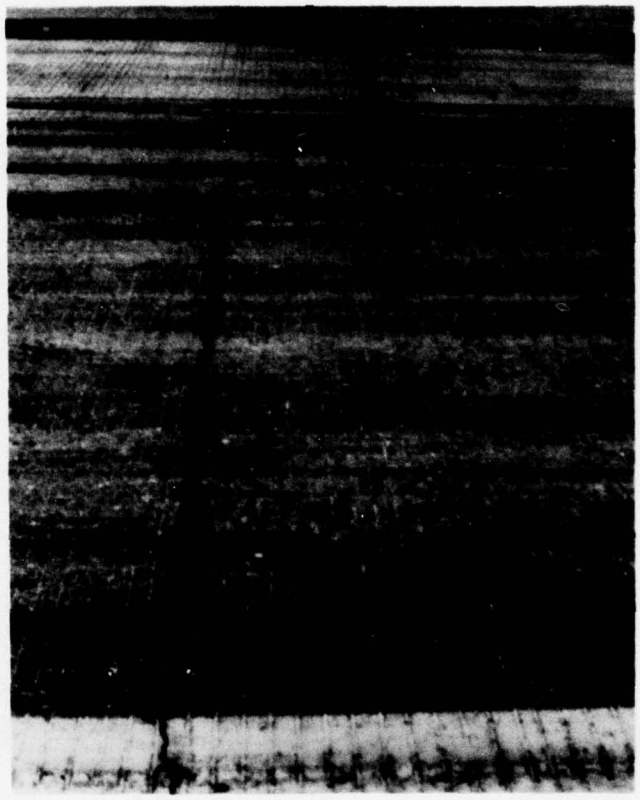

Figure 4 - Runway Cracks Identified During Runway Survey

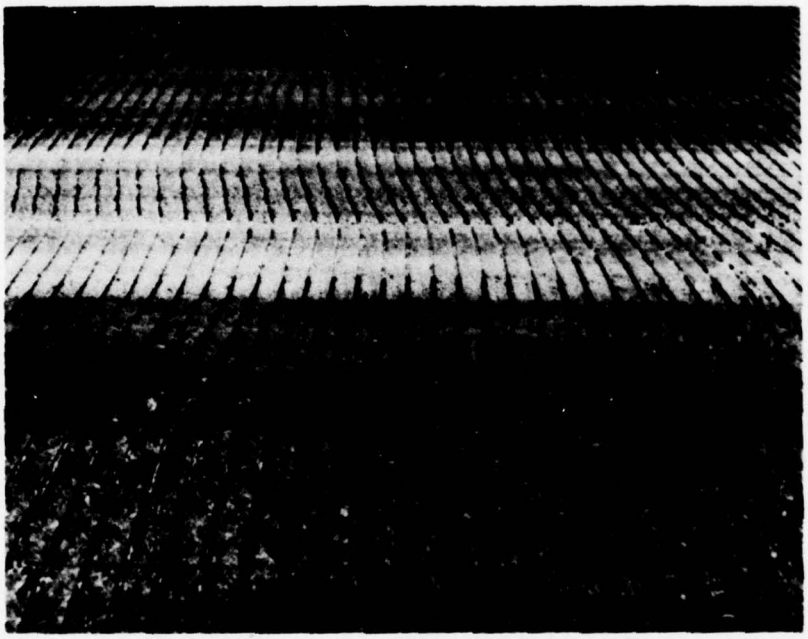

Figure 5 - Migrating Identified During Runway Survey

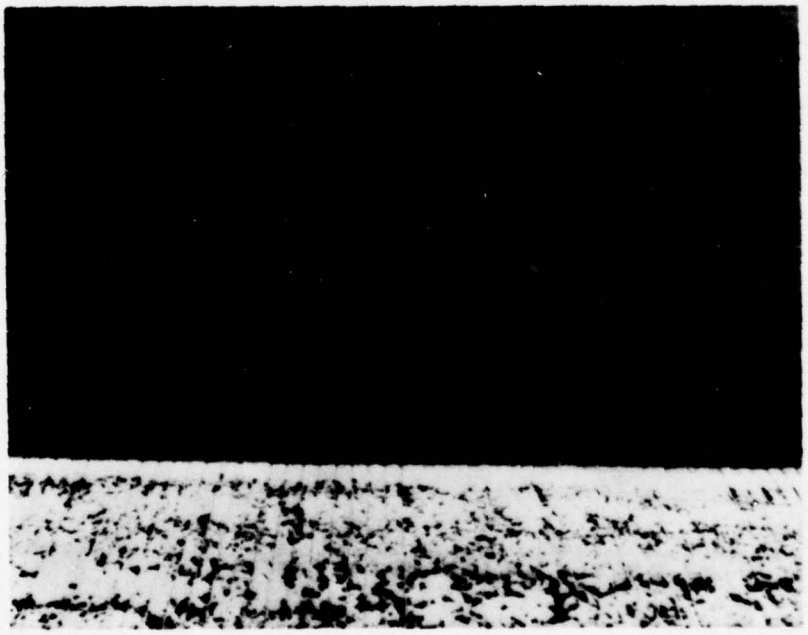

Figure 6 - Deep/Shallow Cut Identified During Runway Survey

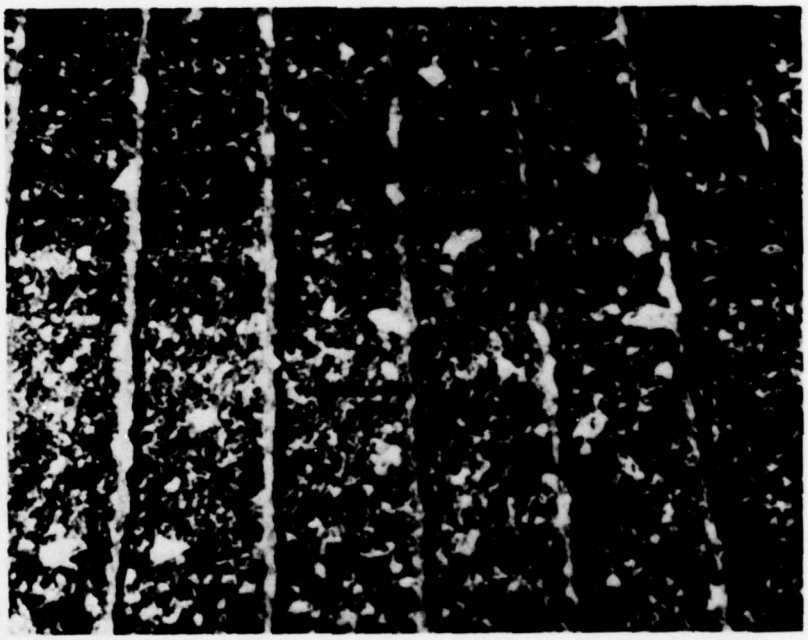

Figure 7 - Rounding Identified During Runway Survey

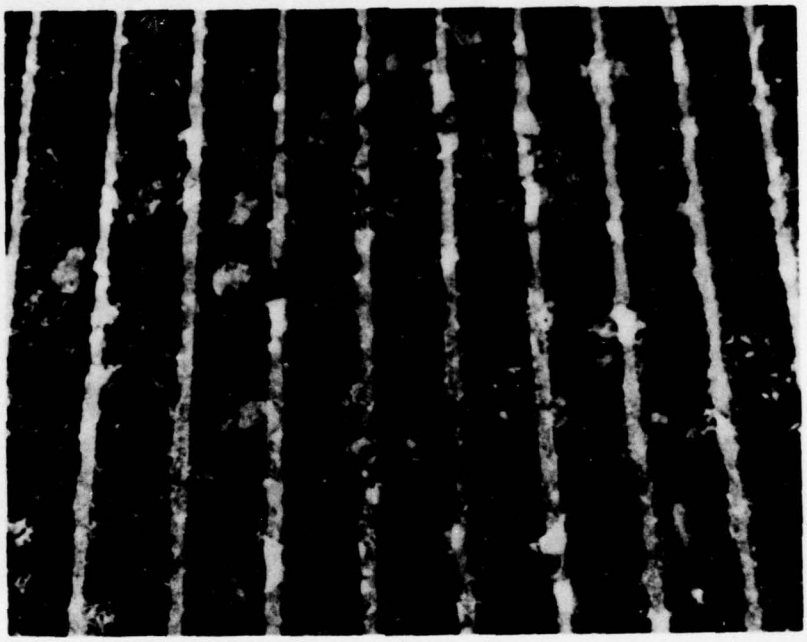

Figure 8 - Spalling Identified During Runway Survey

Figure 9 - Chipping (Breaking Away of Aggregate and/or Filler Material) Identified During Runway Survey

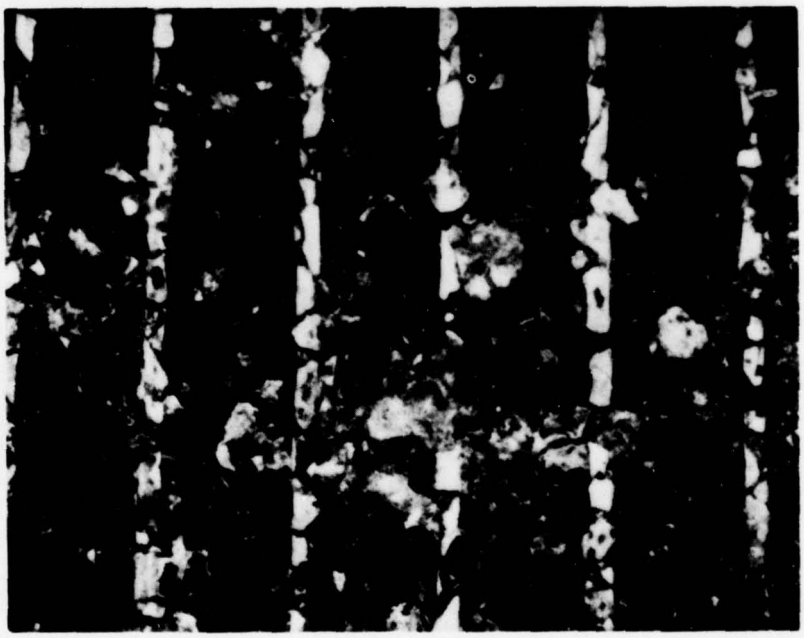

Figure 10 - Erosion Discovered on Runway During Survey

Figure 11 - Cold Seam Cracking Discovered During Runway Survey

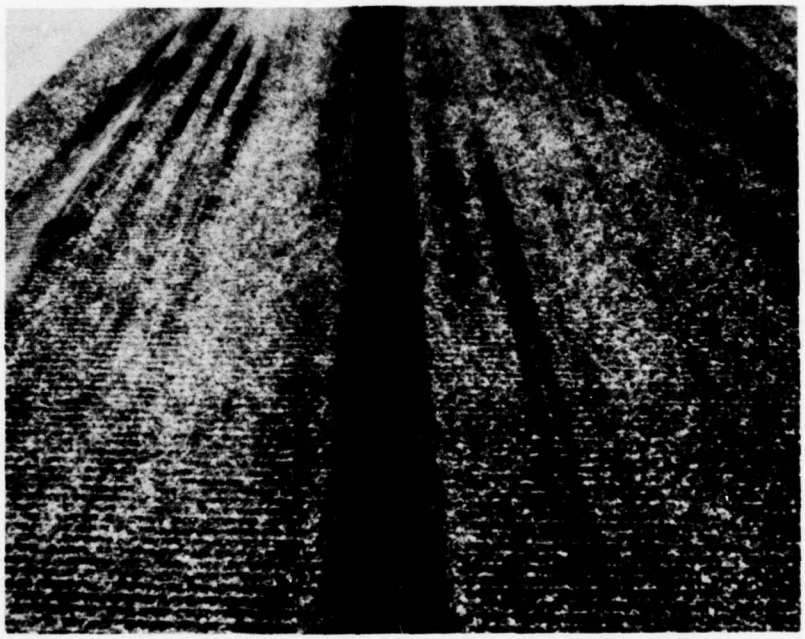

Figure 12 - Ungrooved Patch Discovered During Runway Survey

RUNWAY GROOVE INSPECTION DATA

AIRPORT: CHATTANOOGA RUNWAY: 02/20 DATE: 21 MAR 78

MAP KEY	LOCATION OF DAMAGED AREA: FROM 02 END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS (1/4 — 1" — 1/4): WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-100	C/L TO 50L	5000	1, 2	0, 1/16, 1/4	1/16, 1/4	1-1/4	WAVY PATTERN	PATTERN ITSELF SHOULD NOT AFFECT TRACTION-DISTORTION DUE TO AIRCRAFT TURNING ONTO RUNWAY & HEAT.
	0-100	C/L TO 50L		3	1/4	1/16	1-1/4	WEAR	
	0-100	C/L TO 50L			1/16, 1/4	1/8, 1/16	1-1/4	MOD. CLOSING	
2	900	25 R&L		4, 5	0, 1/4	1/8, 1/4	1-1/4	RUBBER IN GROOVE	
3	3340	25 R&L			1/4	1/8, 1/4	1-1/4		PRIMARY TURNOFF R/W 02
4	4740	25 R&L		6	1/8, 1/4	1/16, 1/8	1-1/4		PRIMARY TURNOFF R/W 20
5	6200	25 R&L			3/16, 1/4	1/8, 1/4	1-1/4		
6	7300	25 R&L			1/4	1/8, 3/16, 1/4	1-1/4		
7	7300	R/W EDGE			1/4	1/8, 1/4	1-1/4		DEPTH AT RUNWAY EDGE BELOW STANDARD

RUNWAY GROOVE INSPECTION DATA

AIRPORT: CINCINNATI RUNWAY: 18/36 DATE: 22 MAR 78

MAP KEY	LOCATION OF DAMAGED AREA: FROM 18 END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH (1/4 – 1/4)	GROOVE MEASUREMENTS: DEPTH (1/4 – 1/4)	GROOVE MEASUREMENTS: SPACING (← 1-1/4 →)	NATURE OF DEFECT	COMMENTS
1	500	25 L&R		1, 2	1/16, 1/4	0, 1/16, 3/16	1-1/2		EVERY 30" ONE GROOVE WAS CUT 1/16" WIDE
2	500	R/W EDGE			1/16, 1/4	3/16, 1/4	1-1/2		
3	1500	C/L		3, 4	-	-	-		TARRED AREAS NOT REGROOVED
4	2160	25 L&R		5	1/4	1/16, 1/4	1-1/2		TURNOFF AREA (FOX TROT). UNGROOVED AREAS NEAR C/L LIGHTS
5	-	5' R	1' x FULL LENGTH OF RUNWAY	6	-	-	-	PATCH	JOINT IN PAVEMENT CRACKED & WAS PATCHED BUT NOT REGROOVED
6	3130	25 L&R		8, 9	1/4	1/16, 1/4	1-1/2	WEAR, SOME ROUNDING	TURNOFF C. DEPRESSED AREAS WITH SHALLOWER GROOVES
7	4400	25 L&R		10, 11	1/4	1/8, 1/4	1-1/2	CHIPPING, ROUNDING	
8	4840	25 L&R	600	12	1/4	1/8, 3/16	1-1/2		LARGE PATCHED AREA NOT REGROOVED
9	5700	15 R		13	-	-	-	POP-OUT	
10	5800	25 R&L		14, 15	1/4	1/8, 1/4	1-1/2		TURNOFF E. DEEP & SHALLOW GROOVES SIDE BY SIDE
11	9500	25 R&L			1/4	3/16, 1/4	1-1/2		

RUNWAY GROOVE INSPECTION DATA

AIRPORT: PHILADELPHIA RUNWAY: 9R/27L DATE: 29 MAR 78

MAP KEY	LOCATION OF DAMAGED AREA: FROM 27L END STATION	LOCATION OF DAMAGED AREA: FELT LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	1200	25' L&R			1/4	3/16	1"		
2	2000	25' L&R		1, 2	1/8-3/16	3/32-3/6	1"	RUBBER BUILDUP	SOME ROUNDED EDGES - BRAKING AREA
3	3700	50 R		3, 4	1/4	3/16-1/4	1"	POP-OUT	TURN AREA - LITTLE WEAR
4	5500	50 R		5	1/4	1/8 - 7/32	1"		GROOVE DEPTH VARIED IN ADJACENT GROOVES DUE TO CUTTING BLADE MISALIGNMENT, NOT WEAR
5	6800	50 R	10	6	1/4	3/16-1/4	1"	SPALLING	TURN CC. MINOR SPALLING IN SEVERAL AREAS
6	9300	25' L&R			1/4	1/32-7/32	1"		9R TOUCHDOWN - VARIOUS DEPTHS IN ADJACENT GROOVES

RUNWAY GROOVE INSPECTION DATA

AIRPORT: JACKSONVILLE RUNWAY: 7/25 DATE: 4 APR 1978

MAP KEY	LOCATION OF DAMAGED AREA: STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0 -150	RT Edge to CL	7500	1,2	0-1/4	1/4-5/32	1-3/4	Closing	
2	1200	25 L & R		3	1/4	1/8-1/4	"	Mod. wear	Rubber deposits--not measurable
3	1300	25 L &R		4,5	1/4	1/8-1/4	"		Rubber deposits, varying depth caused by surface contour
4	2500	50R	100	6	3/16	1/8-1/4	"	Contaminents	Caked dirt in grooves. Turn-off G
5	2900	25 L & R		7	3/16	1/4	"	Lipping over	
6	4600	25 L & R			1/4	1/8-1/4	"	Light wear	
7	5900	25 L & R		8	3/16	3/16	"		Rubber deposits
8	6500	25 L & R		9	3/16	1/16-1/4	"	Wear	
9	6500	50R			1/4	3/16	"	Contamin[illegible]	Caked dirt in grooves similar to Sta 2500--Turn area not extensive
10	7000	25 L & R		10	1/4	3/16	"	Rubber	Slight wavyness. Varying depth caused by surface contour.
11	8000	RT edge to CL			1/4	1/32-1/4			Wavyness and uneven depths.

RUNWAY GROOVE INSPECTION DATA

AIRPORT: FT LAUDERDALE RUNWAY: 27R/9L DATE: 6 APR 1978

MAP KEY	LOCATION OF DAMAGED AREA: STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-100	L/edge to C/L	5000	1,2,3	1/8-1/4	1/8-1/4	1-1/4	Closing & Pop-out	
2	1000	L/edge to C/L	6000	4,5,6,7	0-3/16	0-13/32	1-1-1/4	Closing flowing wear	Extreme case of asphalt flowing causing distortion of pattern, cracking,etc. Area scheduled for resurfacing.
3	1200	25'L & R		8	1/16-1/8	7/32	1-1/4	Closing contaminents	Touchdown area. Rubber deposits clogging grooves
4	1300	15L & R	10000	9	-	-	-	Wavy pattern	Asphalt flowing
5	1400	25L & R			1/8-3/16	-	1-1/4	Closing	
6	3000	15L & R		10	1/8-3/16	-	-	Closing	
7	4000	15L & R		11	0-1/4			Closing	
8	5500	25L & R		12	3/16	1/4	1-1/4	Contaminents wavyness	Rubber deposits & mod. asphalt flowing.
9	6800	25L & R		13	3/16	3/16-9/32	1-1/4	Contaminents	Heavy rubber deposits clogging curves
10	8000	L/Edge to CL		14,15	0-1/4	3/16-1/4	1-1/4	Rounding, closing	Turn-on area

RUNWAY GROOVE INSPECTION DATA

AIRPORT: MIAMI INTERNATIONAL RUNWAY: 9L/27R DATE: 7 APR 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 9L STATION	LOCATION OF DAMAGED AREA: LEFT LIFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-150	Rt edge to 25L	10000	1,2	0-1/4	3/32-3/16	1-1/4	Closing	Extensive closing where a/c turn onto runway.
2	800-1300	25' L & R	12500	3,4,5	0-1/4	0-3/8	1-1/4-1-3/4	Contaminents	Heavy rubber deposits clogging grooves
3	2600	On-center		6	1/16-1/4	1/8-3/16	1-1/4	Contaminents	Paint in grooves
4	4800	25'L & R		7	0-3/16	3/32-5/32	1-1/4	Closing	
5	4900	25'L & R		8,9,10	0-3/16	0-3/16	-	Closing	Mod. wear
6	7500	25'L & R			1/4	1/8-1/4	1-1/4	Rounding	
7	9000	25'L & R		11	0-1/4	3/16	-	Pop-Out	Some rubber buildup and rounding
8	10200	RT Edge to C/L			0-1/4	3/16	-	Closing	Some rounding, not bad compared with 9L threshold.

RUNWAY GROOVE INSPECTION DATA

AIRPORT: JOHN F. KENNEDY RUNWAY: 13L/31R DATE: 13 APR 1978

MAP KEY	LOCATION OF DAMAGED AREA From 13L end STATION	LOCATION OF DAMAGED AREA LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS WIDTH	GROOVE MEASUREMENTS DEPTH	GROOVE MEASUREMENTS SPACING	NATURE OF DEFECT	COMMENTS
1	0-150	Edge-Edge	150' x 75'	1	5/16 - 3/8	0 - 1/8	1 - 1/4"	Extreme wear	TRAPEZOIDAL PATTERN INITIALLY. GROOVES NOW APPEAR RECTANGULAR.
2	1000	50L & R	75' x 75'	2	5/16	0 - 1/16	1 - 1/4"	Extreme wear	MANY SPOTS WORN COMPLETELY FLAT. DEPTHS AVERAGE APPROX 1/32"
3	1100	50L & R		3	5/16	0 - 1/16	1 - 1/4"	Extreme wear	
4	1200	50L & R		4	5/16	0 - 1/16	1 - 1/4"	Extreme wear	IN SEVERAL AREAS ADJACENT GROOVES WERE CUT TO DIFFERENT DEPTHS.
5	6000	50L & R	75' x 75'	5, 6, 7	5/16	0 - 1/16	1 - 1/4"	Wear & rubber paint	BRAKING AREA BOTH DIRECTIONS. SLIGHT MIGRATING OF GROOVES.
6	6000	25L & R		8, 9	-	-	-	Extreme wear	TURN ECHO-GROOVES WORN FLAT NEAR CENTERLINE.
7	7600	25L & R		10, 11	5/16	0 - 1/8	1 - 1/4"	Wear & migrating	4L/22R CROSS RUNWAY
8	9800 - 10000	Edge-Edge		-	5/16	1/8	1 - 1/4"		AVERAGE DEPTH 1/8" VERY LITTLE TRAFFIC THIS END—NO RUBBER.

REPORT NO: NAEC-TD-MISC-R8

REPORT NO: NAEC-TD-MISC-R8

RUNWAY GROOVE INSPECTION DATA

AIRPORT: LA GUARDIA RUNWAY: 4/22 DATE: 13 APR 78

MAP KEY	LOCATION OF DAMAGED AREA: FROM 22 END STATION	LOCATION OF DAMAGED AREA: LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
									FIRST 2000' (FROM 22 END) ARE CONCRETE WITH TRAPEZOIDAL GROOVES. LAST 4200' (FROM 22 END) ARE ASPHALT WITH A COMBINATION OF ASPHALT & RECTANGULAR GROOVES. SEE SKETCH
1	3000	25L & R		1	1/4 x 5/16	1/4	1-1/4	-	NEAR TURN Q NEWLY GROOVED AREA.
2	4000	25L & R		2,3	1/4 - 5/16	1/4	1-1/4	-	BRAKING AREA - NO DEFECTS
3	5200	25L & R		4,5,6	1/4 - 5/16	1/16 - 3/16	1-1/4	WEAR, CLOSING	ISOLATED WEAR SPOTS AND AREAS OF CLOSING TOGETHER. IN GENERAL GROOVES OK.
4	6500	25L & R		7,8	1/4 - 5/16	3/16	1-1/4	RUBBER PAINT	TOUCHDOWN AREA. RUBBER CLOGGING GROOVES. PAINT IN C/L GROOVES
5	1500	25L & R		9	-	-	-	WEAR	CONCRETE PORTION OF RUNWAY

RUNWAY GROOVE INSPECTION DATA

AIRPORT: NEWARK INTERNATIONAL RUNWAY: 22L/4R DATE: 18 APRIL 1978

MAP ID.Y	LOCATION OF DAMAGED AREA: FROM 22L END STATION	LOCATION OF DAMAGED AREA: FELT LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	200-400	Edge to Edge	150 x 200'	1, 2	3/8	3/32-3/16	1-1/8 - 1-1/4	WEAR	AIRCRAFT TURN ON BEFORE GROOVED AREA. AVERAGE DEPTH 1/8". 3/16" MAXIMUM DEPTH.
2	1000	50 L&R		3	3/8	1/8	1-1/8 - 1-1/4	WEAR	GROOVES 20' L&R (MAIN GEAR SPAN) FILLED WITH RUBBER.
3	1300	50 L&R		4, 5	3/8	1/8	1-1/8 - 1-1/4	WEAR, RUBBER & PAINT DEPOSITS	
4	2600	50 L&R		6	3/8	3/32 - 5/32	1-1/8 - 1-5/8	WEAR	ALTERNATE PASSES OF DEEP/SHALLOW GROOVES APPROX 2-1/2 FT. WIDE.
5	4500	50 L&R		7	3/8	3/32	1-1/8 - 1-5/8	WEAR	MIX IN THIS AREA HAS REDDISH BRICK AGGREGATE WHICH CHIPS OUT.
6	5500	50 L&R		8	-	-	-	POOR CUT	TURN E DEFFECTIVE. GROOVING BLADES CUT 2 LEVEL GROOVES IN THIS AREA.
7	8000	50 L&R		9	3/8	3/32	1-1/8 - 1-1/2	WEAR, RUBBER	
8	9700	Edge to Edge		10	3/8	3/32	1-1/8 - 1-5/8	WEAR	MINOR MIGRATING OF GROOVES

RUNWAY GROOVE INSPECTION DATA

AIRPORT: ALLENTOWN-BETHLEHEM-EASTON RUNWAY: 24/6 DATE: 20 APR 1978

MAP KEY	LOCATION OF DAMAGED AREA: STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-200	LEFT EDGE TO 25R		1,2,3	0-3/16	3/32-1/4	1-1/4	CLOSING,WEAR	SLIGHT MIGRATION OF GROOVES NOTICEABLE
2	1300	25'L & R		4	1/8-1/4	1/8 - 3/8	1-1/4	CLOSING,RUBBER	TOUCHDOWN AREA
3	2000	25'L & R		5	0-3/16	1/16 - 5/32	1-1/4	CLOSING	CROSS RUNWAY AREA
4	2800	25'L & R		6, 7	0-3/16	0-7/32	1-1/4	CLOSING,WEAR	HEAVY WEAR IN SOME AREAS
5	3000	25'L & R		8, 9	0-3/16	1/8-3/16	1-1/4	CLOSING,WEAR	TURN E. ALTERNATE PASSES OF DEEP-SHALLOW GROOVES APPROX 2-1/2-FEET WIDE
6	4400	25'L & R		10	0-1/4	1/16-3/8	1-1/4	CLOSING	ALTERNATE PASSES OF DEEP-SHALLOW GROOVES AS CUT 2-1/2 FEET WIDE
7	4800	25'L & R		11,12	0-3/16	5/32-3/8	1-1/4	CLOSING,RUBBER ROUNDING	MINOR MIGRATING OF GROOVES CROSS RUNWAY AREA
8	5000	25'L & R		13	1/16-3/16	1/8 - 3/16	1-1/4	RUBBER, ROUNDING	ROUCHDOWN FOR 6 RUNWAY
9	5800	LEFT EDGE TO 25R		14	0-3/16	0-5/32	1-1/4	CLOSING,ROUNDING	

RUNWAY GROOVE INSPECTION DATA

AIRPORT: GREATER PITTSBURGH INTERNATIONAL RUNWAY: 10R/28L DATE: 25 APR 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 10R END STATION	LOCATION OF DAMAGED AREA: LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS (1/4 – 1/4 – 1 1/2): WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-300	EDGE TO EDGE		1, 2, 3	3/16-1/4	3/32 - 5/32	1-1/2 - 1-5/8	WEAR CLOSING CRACKING	ALTERNATE PASSES OF DEEP/SHALLOW GROOVES AS CUT.
2	1,000 - 1,300	25L & R		4, 5	3/16	3/32	1-5/8 - 1-3/4	WEAR, CRACKING	TOUCHDOWN AREA CRACKS PROPAGATING ALONG GROOVES
3	2,000	15R		6	-	-	-	MIGRATING	MINOR - SHOULD NOT AFFECT HYDROPLANING
4	4,500	25R - L EDGE		7, 8, 9	3/16	3/32	1-5/8 - 1-3/4	WEAR, CRACKING CLOSING	HIGH-SPEED TURN-OFF CRACKING PROPAGATING ALONG GROOVES, MINOR MIGRATING
5	6,900	25L & R		10	1/4	3/32 - 1/8	1-5/8 - 1-3/4	WEAR	TAXI-B. HEAVY BRAKING AREA
6	8,800	25L & R		11, 12	3/16	1/8	1-5/8 - 1-3/4	WEAR, CRACKING SPALLING	TOUCHDOWN
7	9,700 - 10,000	EDGE TO EDGE			3/16-1/4	3/32	1-5/8 - 1-3/4	WEAR	TURN-ON AREA

RUNWAY GROOVE INSPECTION DATA

AIRPORT: KANAWHA (CHARLESTON, W. VA) RUNWAY: 5/23 DATE: 27 APR 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 05 END STATION	LOCATION OF DAMAGED AREA: FELT LIFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS (1/4" wide, 1/4" deep): WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
									CENTER 60' OF RUNWAY IS CONCRETE (SEE SKETCH) GROOVES IN BOTH ASPHALT & CONCRETE SECTION ARE IDENTICAL.
1	0-200	EDGE TO EDGE		1,2,3	1/4	5/32	1"	NONE	ASPHALT & CONCRETE
2	1,000	EDGE TO EDGE			1/4	9/32	1"	NONE	CONCRETE
		EDGE TO EDGE		4,5	7/32	3/32	1"	NONE	ASPHALT
3	3,700	EDGE TO EDGE		6	1/4	7/32	1"	CHIPPING	CONCRETE CHIPPING, ASPHALT OK.
4	4,500	EDGE TO EDGE		7	-	-	-	-	VERY LITTLE RUBBER
5	5,100	EDGE TO EDGE		8,9	1/4	1/4	1"	NONE	
6	6,100	EDGE TO EDGE		-	1/4	1/4	1"		CONCRETE
		EDGE TO EDGE			3/16-1/4	3/16	1"	NONE	ASPHALT

RUNWAY GROOVE INSPECTION DATA

AIRPORT: ALBANY COUNTY RUNWAY: 1/19 DATE: 2 MAY 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 1 END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-200	EDGE TO EDGE		1	1/4	3/16 - 1/4	1"		GROOVES IN EXCELLENT CONDITION
2	1200	25' L&R		2, 3, 4	1/4	3/16 - 1/4	1"		TOUCHDOWN AREA
3	2100	25' L&R		5, 6, 7	1/4	3/16 - 1/4	1"	CHIPPING EROSION	TURN E. ISOLATED SPOTS OF WEAR AND EROSION OF FILLER.
4	3200	25' L&R		8, 9	1/4	3/16 - 1/4	1"	EROSION	
5	4200	25' L&R	2' BY 120'	10, 11	0 - 1/4	0 - 1/4	1"	CLOSING, EROSION	CLOSED GROOVES APPROX 10' RT OF CL. ISOLATED MATERIAL.
6	4600	25' L&R		-	0 - 1/4	-	-	CLOSING	
7	5000	25' L&R		-	1/4	1/4 - 9/32	1"		TOUCHDOWN AREA.
8	6000	25' L&R	1/2' x 1/2'	12	1/4	1/8-1/4	1"	SQUASH	ONE SMALL AREA WAS FOUND SQUASHED IN THRESHOLD AREA.

RUNWAY GROOVE INSPECTION DATA

AIRPORT: ERIE INTERNATIONAL, ERIE, PA RUNWAY: 6/24 DATE: 9 MAY 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 06 END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS (1/4 wide, 1/4 deep, 1-3/4 spacing): WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-200	EDGE TO EDGE		1,2,3	1/4	1/4	1-3/4	CRACKING	
2	1,200	25' L&R		-	1/4	1/4-1/2	1-3/4	CRACKING	
3	1,500	25' L&R		4,5	-	-	-	CRACKING	TOUCHDOWN, TURN-OFF AREA OK, EXCEPT FOR CRACKING.
4	2,000	25' L&R		-	1/4	1/8-3/8	1-3/4	CRACKING	
5	3,000	25' L&R		6	1/4	5/16-3/8	1-3/4	CRACKING	
6	5,000	25' L&R		7,8	1/4	3/8-1/4	1-3/4	CRACKING RUBBER	RUBBER DEPOSITS ONLY ON SURFACE. CRACKS PROPAGATING ALONG GROOVES SPREAD GROOVES TO 1/2" IN SOME CASES
7	5,800 - 6,000	EDGE TO EDGE		9, 10	1/4	1/4	1-3/4	CRACKING	

RUNWAY GROOVE INSPECTION DATA

AIRPORT: CLEVELAND-HOPKINS INTERNATIONAL RUNWAY: 10L/28R DATE: 10 MAY 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 10L END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS (1/4" / 1/4"): WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-200	25' L&R		1,2,3,4	1/4	3/16-1/4	1-1/4	CRACKING	WIDE CRACKS PROPAGATING PARALLEL TO RUNWAY ALONG COLD SEAM & PERPENDICULAR TO RUNWAY ALONG GROOVES
2	1,000	25' L&R		5	1/4	3/16-1/4	1-1/4	CHIPPING	MINOR
3	1,500	25' R	10	6	-	-	-	SPALLING	
4	3,000	25' L&R		7	1/4	1/8-1/4	1-1/4	CRACKING	
5	3,500	25' L&R		-	1/4	0-1/4	1-1/4	CRACKING	
6	4,600	10' L		8,9	0 - 1/4	3/16-1/4	1-1/4	CLOSING WEAR	LOCALIZED CLOSING. NOT EXTENSIVE EXTENSIVE. DEEP/SHALLOW GROOVES.
7	5,000	10' L		10,11,12	1/4	0 - 3/8	1-1/4	MIGRATING CHIPPING, RUBBER	TOUCHDOWN AREA SURFACE COATED W/ RUBBER. LITTLE RUBBER IN GROOVES. MIGRATING 10'L FOR APPROX 50 FEET.
8	5,800	25' L&R		13	1/4	1/8-1/4	1-1/4		

RUNWAY GROOVE INSPECTION DATA

AIRPORT: CHICAGO O'HARE INTERNATIONAL RUNWAY: 14L/32R DATE: 16 MAY 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 14L END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS (1" / 1/4 / 1/4): WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-400	EDGE - EDGE		1,2,3	3/16-1/4	1/8	1"	WEAR	MINOR RUBBER DEPOSITS IN GROOVES
2	1,000	50' L&R		4,5,6	3/16-1/4	3/16-CRACKING	1"	HEAVY RUBBER	MINOR CLOSING
3	1,500	25' L&R		7	3/16-1/4	5/32-1/4	1"	HEAVY RUBBER	SOME ROUNDING & CHIPPING
4	1750	25' L&R		8	3/16-1/4	0-1/4	1"	HEAVY RUBBER CLOSING	GROOVES COMPLETELY FILLED W/RUBBER IN MANY AREAS
5	2000	25' L&R		9	3/16-1/4	3/16	1"	RUBBER CRACKING	
6	2400	25' L&R		-	3/16-1/4	5/32	1"	WEAR RUBBER	
7	3000	25' L&R		10	3/16-1/4	5/32	1"	CRACKING	CRACKS PERPENDICULAR TO CL ACROSS ENTIRE RUNWAY.
8	3500	25' L&R			3/16-1/4	9/32 - 1/4	1"	CRACKING	REFLECTION CRACKS FROM CONCRETE SUB-SURFACE
9	4000	25' L&R		11	3/16-1/4	1/8 - 1/4	1"	CRACKING	REFLECTION CRACKS
10	4500	25' L&R		-	3/16-1/4	3/16	1"	CRACKING	
11	5000	25' L&R		-	3/16-1/4	1/8-1/4	1"	CRACKING	REMAINDER OF RUNWAY IS IN PROCESS OF BEING OVERLAID AND WAS UNAVAILABLE FOR INSPECTION. RUNWAY 32R IS NOT HEAVILY USED. 14L IS PRIMARY.

RUNWAY GROOVE INSPECTION DATA

AIRPORT: MINNEAPOLIS, ST. PAUL INTERNATIONAL RUNWAY: 11R/29L DATE: 17 MAY 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 11R END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-300	EDGE TO CL		1,2,3	1/8-1/4	0-1/4	1-3/4	WEAR CRACKING	MINOR MIGRATING & LOCALIZED CLOSING NEAR CL
2	1000	25' L&R		4,5	1/4	5/32	1-3/4	HEAVY RUBBER CRACKING	TOUCHDOWN AREA. CRACKS PROPAGATE ALONG GROOVES
3	2000	25' L&R		-	1/4	5/32	1-3/4	HEAVY RUBBER	
4	4200	25' L&R		6,7	1/8-1/4	1/32-1/4	1-3/4	WEAR, CLOSING	
5	6200	25' L&R		8,9	1/4	3/16	1-3/4	CLOSING, CRACKING	MINOR MIGRATING, BRAKING AREA
6	7600	25' L&R		10,11,12	1/4	1/8	1-3/4	CRACKING, RUBBER	SEVERAL ROWS OF DEEP/SHALLOW GROOVES AS CUT.
7	9000	25' L&R		13	1/4	1/16-7/32	1-3/4	RUBBER	TOUCHDOWN AREA GROOVES COMPLETELY CLOGGED IN SOME AREAS.
8	9700-10,000	L.EDGE TO CL		14	0-1/4	0-1/4	1-3/4	WEAR, CLOSING	

RUNWAY GROOVE INSPECTION DATA

AIRPORT: BOSTON-LOGAN INTERNATIONAL RUNWAY: 15R/33L DATE: 23 MAY 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 15R END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH (1/4 – 5/16; 2" – 1-5/16)	GROOVE MEASUREMENTS: DEPTH	GROOVE MEASUREMENTS: SPACING	NATURE OF DEFECT	COMMENTS
1	0-300	RT EDGE-CL		1,2,3,4	0-5/16	0-1/4	1-15/16	CLOSING MIGRATING	CONSIDERABLE MIGRATION OF GROOVES IN TURN-ON AREA
2	1000	25' L&R		5	3/16-5/16	1/8-1/4	1-15/16	RUBBER	
3	4000	25' L&R		6	3/16-5/16	5/32-1/4	1-15/16	MIGRATING, CHIPPING, SPALLING	HEAVY BRAKING AREA
4	4900	25' L&R		7,8	0-5/16	5/32-1/4	1-15/16	CLOSING, CHIPPING	HEAVY BRAKING AREA
5	5500	25' L&R		9,10	0-5/16	5/32-1/4	1-15/16	CLOSING	HEAVY BRAKING AREA
6	6600	25' L&R		11,12	0-5/16	3/32-1/4	1-15/16	CLOSING HEAVY, RUBBER CHIPPING	
7	9000	25' L&R		13	5/16	1/4	1-15/16	HEAVY RUBBER	TOUCHDOWN AREA
8	9800 - 10081	RT EDGE-CL		14,15	1/4-5/16	1/4	1-15/16	RUBBER SPALLING CLOSING	

RUNWAY GROOVE INSPECTION DATA

AIRPORT: WASHINGTON NATIONAL RUNWAY: 15/33 DATE: 24 MAY 1978

MAP KEY	LOCATION OF DAMAGED AREA: FROM 15 END STATION	LOCATION OF DAMAGED AREA: FEET LEFT OR RIGHT OF CENTER LINE	AREA DAMAGED (APPROX.) (Ft.Sq.)	PHOTO NUMBER	GROOVE MEASUREMENTS: WIDTH (1/4)	GROOVE MEASUREMENTS: DEPTH (1/2)	GROOVE MEASUREMENTS: SPACING (1/4)	NATURE OF DEFECT	COMMENTS
1	0-300	RT EDGE-C/L		1,2	1/8-1/4	5/32-1/4	1-3/8 - 1-1/2	CLOSING	RUNWAY GROOVED SPRING 1976
2	1000	25' L&R		3	1/8-1/4	5/32-1/4	1-3/8-1-1/2	RUBBER EROSION	TOUCHDOWN AREA. EROSION OF FILLER MATL LEAVING EXPOSED AGGREGATE.
3	1500	25' L&R		-	1/4	1/8-7/32	1-3/8-1-1/2	MINOR CLOSING	ALTERNATE PASSES OF DEEP/SHALLOW GROOVES AS CUT
4	3000	25' L&R		4,5	0-1/4	0-7/32	1-3/8-1-1/2	CLOSING	
5	3600	25' L&R		6,7	1/4	5/32-1/4	1-3/8 - 1-1/2	MINOR RUBBER	RUBBER ON SURFACE ONLY.
6	4000	25' L&R		8,9	1/4	3/16-1/4	1-3/8-1-1/2	EROSION, SPALLING, CHIPPING	TOUCHDOWN AREA.
7	4500	25' L&R		10	1/4	3/16	1-3/8-1-1/2	SPALLING	TOUCHDOWN AREA.
8	5000 - 5200	RT EDGE TO CL		11	1/4	5/32-1/4	1-3/8-1-1/2	EROSION	

APPENDIX B - INDIVIDUAL INSPECTION REPORTS SUPPLIED TO THE FAA FOLLOWING EACH AIRPORT VISIT

1. Jacksonville International Runway 7/25: Grooves in Runway 7/25 were cut in late 1974. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 2-inch center-to-center. Measurments indicate groove width and spacing conform closely to specifications while depths were somewhat shallower than called for. Minor closing of grooves was noted in the threshold areas and minor wear was evident near the centerline in touchdown and braking areas. The runway was cleaned of rubber one month before our inspection, and therefore, rubber deposits were at a minimum.

2. Ft. Lauderdale-Hollywood International Runway 9L/27R

a. Grooves in Runway 9L/27R were cut in October 1975. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/2-inch center-to-center. An extreme case of asphalt flowing was found at Station 1000, near turn 'M', on Runway 9L. The groove displacement approximated a sinusoidal wave form having an amplitude of 2 to 3 feet and a period of about 10 feet. The airport has already contracted to have the damaged area (approximately 6,000 square feet) repaved and regrooved. Poor asphalt mix or poor subsurface bonding appears to be the probable cause of the flowing. At the primary turnoff, farther down the runway, no such problem was evident.

b. Minor closing of grooves was noted at threshold areas and some rubber clogged grooves were noted in the touchdown areas. Flowing of asphalt (wavy grooves) was also found near the centerline at Station 1300-1400 of Runway 27. Grooved depths generally measured 5/32 inch to 7/32 inch. Spacing was constant at 1-1/4-inch and groove width varied from 3/16 inch to 7/32 inch.

3. Miami International Runway 9L/27R: Grooves in Runway 9L/27R were cut in 1972. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/2-inch center-to-center. Large areas of completely closed grooves were found in the 9L threshold area where aircraft turned onto the runway. Heavy rubber deposits clogged most grooves in the 9L touchdown area, Station 800 to 1300. Minor closing and rounding was evident in this area. Centerline paint was found clogging grooves in several areas. In general, grooves in threshold, touchdown, and braking areas were in poor condition either being closed together completely or clogged with rubber. In areas of no wear near runway edges, grooves measured close to specifications.

4. John F. Kennedy Runway 13L/31R: Grooves in Runway 13L/31R were cut in 1973. Specifications called for a trapezoidal pattern having nominal dimensions of 3/16-inch deep by 3/8-inch wide (top) tapering to 1/8-inch wide (bottom) with a spacing of 1-1/8 inch. The grooves are worn badly the entire length of the runway and appear rectangular in shape. In many

areas the grooves are worn completely flat. No depths in excess of 1/8 inch were recorded. In general, groove widths measured 5/16 inch and groove spacing 1-1/4 inch.

5. LaGuardia Runway 4/22: Grooves in Runway 4/22 were initially cut in 1973, in a trapezoidal pattern identical to Kennedy Airport described above. The damaged portions of the runway have been resurfaced and regrooved with a rectangular groove measuring 1-1/4-inch (spacing) by 1/4-inch deep by 1/4-inch wide. The first 2,000 feet of Runway 22 are concrete and therefore not pertinent to this report, however, this area was inspected and found to be badly worn. Only scattered wear spots were noted near heavy braking and turning areas in the asphalt surfaced portion of the runway. The dimensions of the rectangular grooves in the resurfaced asphalt sections measured close to specification.

6. Newark International Runway 4R/22L

a. Initial plans were to inspect Runway 4L/22R which was grooved in 1970, and is 8,200 feet in length. On the day of our visit the parallel Runway 4R/22L was down for maintenance thus doubling the traffic on 4L/22R and making inspection of that runway unfeasible. Runway 4R/22L, which is an 9,800-foot asphalt runway grooved in 1973, was inspected in lieu of Runway 4L/22R.

b. Specifications for grooves in Runway 4R/22L called for a trapezoidal pattern having nominal dimensions of 3/16-inch deep by 3/8-inch wide (top) tapering to 1/8-inch wide (bottom) with a spacing between grooves of 1-1/8 inches. Grooves appeared rectangular in cross section measuring approximately 3/8-inch wide but only 3/32 to 1/8-inch deep on the average. Alternate passes of deep/shallow grooves were evident throughout the entire length of the runway. Rubber clogged grooves were noted in the touchdown areas. Damaged grooving blades cut defective grooves in several areas. Only minor migrating of grooves was evident.

7. Allentown-Bethlehem-Easton Runway 6/24: Grooves in Runway 6/24 were cut in 1973. Specifications called for a rectangular pattern having nominal dimensions of 1/4-inch deep by 1/4-inch wide with a spacing between grooves of 1-1/4 inches. Closing of grooves was noted in threshold, touchdown, and braking areas. Groove widths measured 0 to 3/16 inch, and depth measured 1/16 to 3/8 inch. Alternate passes of deep/shallow grooves were noted indicating poor control of the grooving machine cutting depth. Slight migration of grooves was found in the Runway 24 threshold.

8. Greater Pittsburgh International Runway 10R/28L: Grooves in Runway 10R/28L were cut in the Spring of 1973. Specifications called for a groove pattern having nominal dimensions of 1/4-inch deep by 1/4-inch wide with a center-to-center groove spacing of 1-3/4 inches. The runway is in poor condition with extensive cracking and spalling the entire length. The surface cracks, for the most part, propagate along the grooves occasionally jumping to adjacent grooves, and extend, in some cases, three or more inches deep. These cracks ranged up to 1/4-inch wide. Poor drainage between the asphalt surface and the concrete subsurface may have precipitated the cracks. The comparitively small size of the aggregate in the asphalt may also have had an effect. In general, groove widths measure 3/16 to 1/4 inch, groove depths 3/32 to 1/8 inch and groove spacing varied from 1-3/4- to 2-inches center-to-center. The runway was cleared of rubber five months prior to inspection and had few, if any, clogged grooves when inspected.

9. Kanawha (Charleston, West Virginia) Runway 5/23: The center 60 feet of Runway 5/23 is concrete for the full 6,300-foot length. Sections of the outer 45 feet on each side are asphalt. The entire runway was grooved in 1969. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide with a center-to-center distance of 1/4 inch for both concrete and asphalt areas. No wear and only minor rubber deposits were evident. At the high-speed turnoff station 3700 (Runway 5), some concrete chipping was found. In general, grooves measured very close to specifications.

10. Chattanooga (lovell Field) Runway 2/20: Grooves on Runway 2/20 were cut in 1974. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch thick by 1-1/4-inch center-to-center. In general, the runway grooves were in satisfactory condition though somewhat shallower than 1/4 inch. A distored (wavy) groove pattern was noted at the approach end of 20 where aircraft turning onto the runway have caused the asphalt to flow. Effectiveness of the grooving should not be diminished, however, since groove widths and depths remain unchanged.

11. Cincinnati (Greater Cincinnati) Runway 18/36: Grooves in Runway 18/36 were cut in 1972. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/2-inch center-to-center. Width and spacing of grooves were satisfactory; however, depths varied from 1/6 inch to 3/16 inch in most areas. Extensive patching near the centerline (bituminous cold joints and centerline light area) has effectively eliminated considerable grooved area. The patches have not been regrooved.

12. Philadelphia International Runway 9R/27L: Grooves on Runway 9R/27L were cut in 1977. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/4-inch center-to-center. The runway surface

is in excellent condition with only occasional wear spots or spalled areas. Depth ranged from 1/8 inch to 1/4 inch while width and spacing was generally to specifications.

13. Albany County Airport, Albany, NY Runway 1/19: Grooves on Runway 1/19 were cut in October 1976. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/4-inch center-to-center. In general, the grooves in Runway 1/19 were in excellent condition. Isolated areas of wear, erosion of filler material, and closing of grooves were noted in turn and touchdown zones. Width and center-to-center spacing of grooves measured 1/4 and 1-1/4-inch, respectively, except for the minor areas of groove closing where the width was reduced to zero. Groove depth measured generally from 3/16 to 1/4 inch.

14. Erie International Airport, Erie, PA Runway 6/24: Grooves on Runway 6/24 were cut in 1975. Specifications called for nominal dimensions of 1/4-inch wide by 1/4-inch deep by 2 inches center-to-center. Extensive cracking was found along the entire runway surface. Cracks extended both perpendicular and parallel to the runway centerline. Those running perpendicular to the centerline generally propagated along the grooves and at times widened the grooves to 1/2 inch or more. These wide cracks probably act as expansion joints, widening and closing as temperatures rise and fall. The grooves themselves are in good condition with minor wear, minimal rubber deposits, and no closing at all being noted. Groove widths measured 1/4-inch, groove center-to-center distances were constant at 2 inches, and groove depths ranged from 1/4 to 3/8 inch.

15. Chicago O'Hare International Runway 14L/32R: Runway 4L/22R was unavailable for inspection due to heavy traffic conditions. Runway 14L/32R, which was down for resurfacing, was inspected instead. Runway 14L/32R is a 10,000-foot runway grooved in October 1974. Runway 4L/22R is a 7,500-foot runway grooved in 1976. Groove specifications for runway 14L/32R called for nominal dimensions of 1/4-inch wide by 1/4-inch deep with a center-to-center distance of 1-1/4 inches. Moderate wear and cracking were found the entire length of the runway. Heavy rubber deposits clogged grooves in the touchdown zones (Station 1000 to 2000). Groove widths measured 3/16 to 1/4 inch, groove depths 1/8 to 1/4 inch (except where rubber deposits completely filled grooves) and groove center-to-center distances were constant at 1-1/4 inch.

16. Minneapolis-St. Paul International Runway 11R/29L: Runway 11R/29L is the only grooved asphalt runway in Minneapolis-St. Paul International Airport. This runway was, therefore, inspected in lieu of runway 11L/29R which is concrete. Runway 11R/29L is a 10,000-foot runway grooved in 1974. Specifications called for nominal dimensions of 1/4-inch wide by 1/4-inch deep with a center-to-center distance of 2 inches. Grooves were worn flat in many areas of both thresholds where aircraft turn onto the runway. In touchdown and braking areas heavy rubber deposits, closing of grooves, wear and cracking were found. Groove widths measured 1/8 to 1/4 inch (except

where completely closed in touchdown areas), groove depths ranged from zero to 1/4 inch and center-to-center distances were 2 inches.

17. Boston-Logan International Runway 15R/33L: Runway 4L/22R, which was grooved in 1975, was unavailable for inspection due to heavy traffic. Runway 15R/33L, which is a 10,000-foot runway grooved in 1972 and 1973, was inspected instead. Specifications called for nominal groove dimensions of 1/4-inch deep by 5/16-inch wide by 2-1/4-inch center-to center. Migration and closing of grooves was noted in the aircraft turn-on areas of Runway 15R. Migrating, chipping, closing, and spalling were found to varying extents in the touchdown areas along with isolated areas of completely rubber clogged grooves. Groove widths ranged from 0 to 5/16 inch groove depths from 0 to 1/4 inch and center-to-center distance 2-1/4 inches.

18. Washington-National Airport Runway 15/33: Grooves on Runway 15/33 were cut in the Spring of 1976. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-3/4 inches center-to-center. Isolated spots of closed grooves were found in threshold and braking areas. Erosion of filler material and spalling were evident the entire length of the runway. Only surface rubber deposits were found. Groove depth measured generally between 5/32 and 1/4 inch, groove width between 1/8 and 1/4 inch and groove center-to-center distance between 1-5/8 and 1-3/4 inches.

19. Cleveland-Hopkins International Airport, Cleveland, Ohio Runway 5R/23L: Runway 5R/23L was the runway selected for inspection at Cleveland-Hopkins, however, this runway has just been overlaid and is not yet grooved. As a substitute, Runway 16L/28R was inspected. This runway is 6,000-feet long and was grooved in 1974. Specifications called for grooves measuring 1/4-inch wide by 1/4-inch deep by 1-1/2 inches center-to-center. Extensive cracking, similar to that at Erie's Runway 6/24 was found. Minor migrating of grooves along with localized closing of grooves (10 feet left of center for 50 feet) was found in the touchdown area, Station 1400, runway 28R. Rubber deposits were limited to the surface in the touchdown area and did not clog the grooves. No appreciable chipping, rounding, or wear was noticed. Groove widths, in general, measure 1/4 inch, depths ranged from 1/8 to 1/4-inch center-to-center.